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Research Note

Sheep Ingestion of Water Containing Quebracho or Black Wattle Tannin

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Abstract

Ingestion of small amounts of condensed tannin (CT) by ruminants can produce valuable outcomes such as improved nitrogen use and reduced bloating, methane output, and gastrointestinal parasitism. However, many grasses and forbs contain little if any CT. The specific types of CT vary in plants and can have somewhat different effects on ruminants. Individual ruminants can respond differently to CT intake. Not all livestock will consistently consume supplements while grazing, but they all usually drink water daily. Therefore, in order to determine how sheep would respond to CT in their drinking water, eight lambs with the same initial weight of 43 kg were individually penned, fed alfalfa pellets twice daily, and had ad libitum access to two waters. Water intake was measured daily. After an adjustment period to pens, feeding, watering conditions, and water containing CT, three sequential week-long trials were conducted. In Trial 1, lambs chose between tap water and a quebracho tannin (QT)–water mixture (0.19% QT w/w; ca. 1% dry matter intake of QT). In Trial 2, lambs chose between tap water and a QT–water mixture of lower concentration (0.14% QT w/w). In Trial 3, lambs chose between a QT–water mixture and a wattle tannin–water mixture, both with the same concentration (0.14% CT w/w). In Trials 1 and 2, lambs had inconsistent intakes of tannin water and tap water from day to day ($P \leq 0.02$) and neither preferred nor avoided tannin solutions. They also had inconsistent daily intakes of the two different tannin solutions offered simultaneously ($P = 0.01$), and showed no preference for either tannin solution ($P \geq 0.15$). Results support other observations that sheep will voluntarily consume water with small amounts of CT in it, and provide no evidence that sheep prefer consuming small amounts of QT vs. black wattle tannin in water.

Resumen

El consumo de pequeñas cantidades de taninos condensados (TC) por rumiantes puede producir resultados valiosos tales como un mejor uso del nitrógeno, reducción del timpanismo, menor producción de metano y disminución en parasitismo gastrointestinal. Sin embargo, muchas de las gramíneas y herbáceas contienen muy poco o casi nada de TC. Los tipos específicos de TC varían entre plantas y pueden tener de alguna manera diferentes efectos en los rumiantes. Cada rumiante puede responder en forma diferente al consumo de TC. No todo el ganado consume suplemento consistentemente en condiciones de pastoreo, pero normalmente beben agua diariamente. Por lo tanto, con el fin de determinar cómo las ovejas responden a TC en el consumo de agua, ocho corderos con el mismo peso inicial de 43 kg se colocaron en corraletas individuales, alimentados con gránulos de alfalfa dos veces al día y con acceso *ad libitum* de dos tipos de agua. El consumo de agua se midió diariamente. Después de un periodo de adaptación a las corraletas, a la alimentación, a las condiciones de los bebederos y al agua que contenía TC, se llevaron a cabo tres experimentos secuenciales con una duración de una semana cada uno. En el experimento 1, los corderos eligieron entre el agua de la llave y una mezcla de agua que contenía taninos de quebracho (QT) (0.19% QT w/w; ca. 1% Consumo de MS de QT). En el experimento 2, los corderos tenían la opción de seleccionar entre el agua de la llave y una mezcla de agua con QT con una concentración menor (0.14% QT w/w). En el experimento 3, los corderos podían seleccionar entre una mezcla de agua de QT y una mezcla de agua con taninos en ambas mezclas con la misma concentración (0.14% CT w/w). En los experimentos 1 y 2, los corderos tuvieron consumos muy inconsistentes tanto de agua con taninos como agua de la llave de día a día ($P \leq 0.02$) y no prefirieron pero tampoco evadieron las soluciones con taninos. También tuvieron consumos diarios inconsistentes de las los soluciones de taninos ofrecidas simultáneamente ($P = 0.01$), y no mostraron preferencia por cualquier solución de taninos ($P \geq 0.15$). Los resultados apoyan otras observaciones que ovejas consumen voluntariamente agua con pequeñas cantidades de TC en ella y no demuestran que ovejas prefieren consumir cantidades pequeñas de quebracho versus tanino de acacia en el agua.

Key Words: condensed tannin, livestock, water intake

INTRODUCTION

Intake of small amounts of condensed tannin (CT) can produce a variety of benefits for ruminant livestock (Min et al. 2003) including reducing the amount of nitrogenous compounds in urine (Egan and Ulyatt 1980; Waghorn et al. 1987a, 1987b;

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Waghorn et al. 1994) and reducing gastrointestinal parasitism (Butter et al. 2001) as well as reducing methane output (Waghorn 2008). There are advantages to having ruminant livestock consume CT in their drinking water, because not all animals will consistently consume solid supplements while grazing, especially when grazing high-quality forage. Sheep and cattle will drink water with small amounts of CT in it (Kronberg 2008). The optimal daily intake of CT when ingested as a constituent of forage appears to be 2–4% of dry matter (DM) intake (Waghorn and Shelton 1995; Min et al. 2003), with less having little or no benefit and more being potentially toxic. This level likely depends on the type of CT ingested (Min et al. 2003), and the optimal daily intake of CT may be lower when consumed in water rather than in plants (Kronberg 2008; Grainger et al. 2009). Also, some CTs have greater toxicity to ruminants (Clausen et al. 1990; Provenza et al. 1990), so some readily available CTs may not be suitable for feeding to ruminants. Also, some CTs may offer greater benefits (Waghorn 2008). For example, Beauchemin et al. (2007) fed quebracho tannin (QT) to beef heifers at 1% or 2% of daily DM intake and found it had no effect on methane emissions. In contrast, when Grainger et al. (2009) dosed black wattle tannin (WT) to dairy cows at 0.9% and 1.8% daily DM intake it decreased methane emission.

Kronberg (2008) reported QT–water intakes by a few black-faced crossbred sheep, but there are genetic differences between individual ruminants in their responses to phytochemicals (Snowder et al. 2001) so more information is needed about how sheep of different breeds respond to QT in their drinking water. Lastly, because ruminants will ingest nutrients and phytochemicals that improve their well-being (Provenza 1995; Phy and Provenza 1998; Villalba and Provenza 2007), it is possible that they would prefer to drink water with small amounts of a specific CT in it. Therefore, the objectives of this study were to determine 1) if sheep preferred to drink water containing QT at either 0.75% or 1% of their daily alfalfa pellet intake and 2) if sheep preferred to drink water containing QT or WT with both at 0.75% of their daily alfalfa pellet intake.

MATERIALS AND METHODS

Eight 8-mo-old Rambouillet wether lambs with the same initial body weight (43 kg) were used in three trials. They were penned individually in 1.5×1.7 m pens in a barn with good air flow and under ambient summer temperatures, and had ad libitum access to tap water and (or) tannin water in 20-L buckets and were fed 1.59 kg of alfalfa (*Medicago sativa* L.) pellets per day (3.7% of body weight $\cdot$ d^{-1}; 94% DM; 17% crude protein, DM basis) at 0700 and 1600 hours for the entire study. Tap water was from a municipal source. Pellet intake was measured for each feeding and usually all pellets were consumed quickly. Daily water intake was measured between 0730 and 0800 hours by determining the amount (kilograms) of water removed from each bucket. Evaporative water losses from the buckets were expected to be very minor and were not measured. In the first part of a pretrial period, tap water was offered to animals for 7 d and mean daily water intake was determined for each animal. These means were then used to determine the amount of CT that was mixed with tap water to provide the animals with desired amounts of daily tannin intake during the trials. We assumed that their daily intake of a tannin–water solution would be similar to their pretrial mean daily water intake, which we found to be a reasonable assumption in an earlier trial with lambs (Kronberg 2008). Liquid forms of QT and WT from the Tannin Corporation (Peabody, MA) were used in these trials. QT is derived from the quebracho tree (*Scinopsis balansae* Engl.) in Argentina. WT comes from the black wattle tree (*Acacia mearnsii* de Wild), originally from Australia but now grown commercially in South Africa. These two tannins were selected for the trial because large quantities are available and research with ruminants has been done with both tannins. In the second part of the pretrial period, sheep were adapted to drinking tannin water by giving them water with increasing amounts of QT in it (providing 0.5%, 0.75%, 1.0%, and 1.25% of their daily intake of alfalfa pellets in CT, assuming they consumed similar amounts of tannin water as normal water, and 7 d of exposure per concentration with no tap water offered during this second part of the pretrial period). When the highest concentration of tannin water was offered and consumed by the sheep, two animals reduced their feed intake considerably and appeared sick, so the concentration designed to deliver 1.25% of their daily feed intake in CT was not used in the trials.

Consistent with the assumptions of analysis of variance (ANOVA) and with another preference tests with fluids (Phy and Provenza 1998), which directly compared preferences for two fluids using ANOVA, the MIXED procedure of SAS (1996) with repeated measures of daily liquid intakes was used to compare liquid intakes between two different liquids for each trial. Type of water was the treatment and daily intake was the repeated measure. Unstructured, compound symmetry, and heterogeneous compound covariance structures were evaluated with each analysis and the structure with the smallest value for Akaike's Information Criterion was used for the analysis.

Trial 1

After the pretrial period, all eight sheep were simultaneously offered both tap water and a QT solution that was created to give them 1% of their daily feed intake as tannin. This trial was conducted for 7 d to determine their intake of the tannin solution when they were able to avoid it and drink tap water. Bucket locations were reversed daily for each sheep for this and subsequent trials.

Trial 2

Immediately following the first trial, all eight sheep were offered both tap water and a QT solution that was created to give them 0.75% of their daily feed intake as tannin. This trial was conducted for 7 d to determine their intake of a more dilute tannin solution when they were able to avoid it and drink tap water.

Trial 3

Immediately following the second trial, all eight sheep were given a choice between tannin–water solutions made with QT or WT for 7 d to determine if they preferred one type of tannin

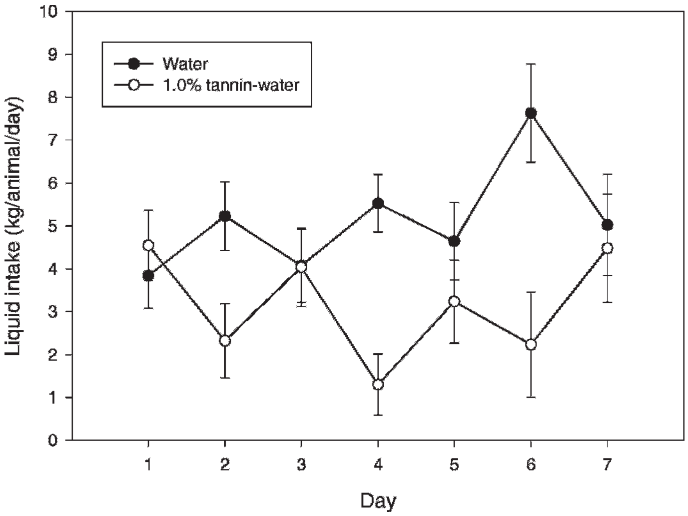

Figure 1. Least squares means of daily intake of a quebracho tannin–water solution (prepared to provide about 1% of daily feed intake in tannin) and water for eight sheep over a 7-d trial (Trial 1). Vertical bars represent the SE associated with the means.

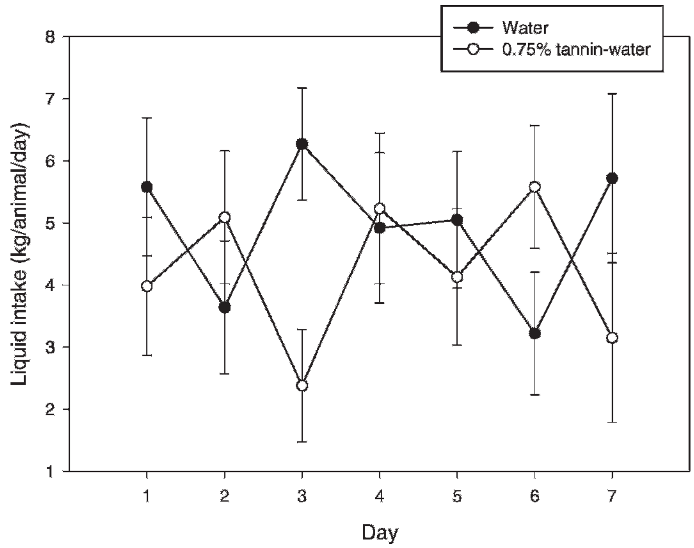

Figure 2. Least squares means of daily intake of a quebracho tannin–water solution (prepared to provide about 0.75% of daily feed intake in tannin) and water for eight sheep over a 7-d trial (Trial 2). Vertical bars represent the SE associated with the means.

water over the other. Sheep had no exposure to WT before this trial, but it was assumed that the sheep could learn to prefer or avoid it during the trial if the postingestive response they received from it was different from the QT. Both tannin–water mixtures were created to give the sheep 0.75% of their daily feed intake as tannin.

RESULTS AND DISCUSSION

Trial 1

During the 7-d preference test between tap water and the tannin–water mixture made to deliver 1.0% of daily feed intake as CT, there was a significant interaction ($P < 0.01$) between treatment and day indicating that there were inconsistent patterns in the mean daily intakes of tap water and tannin water (Fig. 1). On average, sheep showed a preference for tap water over the tannin water on days 2, 4, and 6 of the trial ($P \leq 0.02$), but did not indicate a preference for tap water or tannin water on days 1, 3, 5, or 7 of the trial ($P \geq 0.29$). The standard error (SE) of the least squares means were 0.958 kg and 0.827 kg for intakes of the tap and tannin water, respectively. Although the sheep did not prefer QT water over tap water, on three of the days they drank about as much tannin water as tap water. Kronberg (2008) reported that when four crossbred wether lambs were given a choice between tap water and QT water designed to give them 1.0% of their daily alfalfa pellet intake as tannin, they also had no consistent preference for tap water or tannin water. Together, the earlier study and this study indicate that sheep of differing breed types will drink water with QT tannin in it when tap water is also available. There are two potential explanations for this. First, there is evidence that ruminants will learn to ingest feedstuffs that are associated with their improved protein nutrition, such as protein that is bonded with tannin and therefore protected from ruminal degradation but digested as high quality protein postruminally (Villalba and Provenza 1997). Second, alfalfa contains saponins and ingestion of tannins may counteract the negative effect of saponins by phytochemical–phytochemical inactivation (Freeland et al. 1985); thus ruminants consuming saponins may feel better when they also ingest tannin.

Total mean liquid intake for the whole trial was $57.6\ \mathrm{kg} \cdot \mathrm{sheep}^{-1}$, and mean daily liquid intake averaged across the whole trial was $8.2\ \mathrm{kg} \cdot \mathrm{sheep}^{-1}$. This was similar to mean daily intake of tap water during the pretrial period, which was $8.3\ \mathrm{kg} \cdot \mathrm{sheep}^{-1}$, and similar to results from a previous trial (Kronberg 2008) in which lambs ate similar amounts of alfalfa pellets and had a mean daily intake of $8.4\ \mathrm{kg} \cdot \mathrm{sheep}^{-1}$ of QT water designed to provide 1.0% of their daily feed intake as tannin, but offered without access to tap water. Mean daily tannin water intake averaged across this trial was $3.1\ \mathrm{kg} \cdot \mathrm{sheep}^{-1}$, and mean daily intake of tap water averaged across this trial was $5.1\ \mathrm{kg} \cdot \mathrm{sheep}^{-1}$.

Trial 2

When sheep were offered both tap water and the 0.75% tannin water, their mean ingestion of tap water and tannin water over the 7 d of the trial was inconsistent from day to day ($P = 0.02$ for the treatment by day interaction; Fig. 2). On all but the third day, there was no difference ($P \geq 0.11$) between their average intakes of tap water and tannin water. Mean intake of tap water was greater on day 3 ($P = 0.02$). Therefore, there was no evidence from these results that sheep preferred this slightly more dilute QT water over tap water. However, the SE of the least squares means were 1.030 kg and 1.190 kg for intakes of the tap and tannin water, respectively, so individual variation in daily intake of these two liquids was substantial. Thus, mean daily intakes of the two liquids were not accurate indicators of individual daily intakes. This is important because individual and group productivity may be significantly improved if individuals are given a choice between two or more concentrations of tannin water to allow for individual physiological and behavioral responses to a CT.

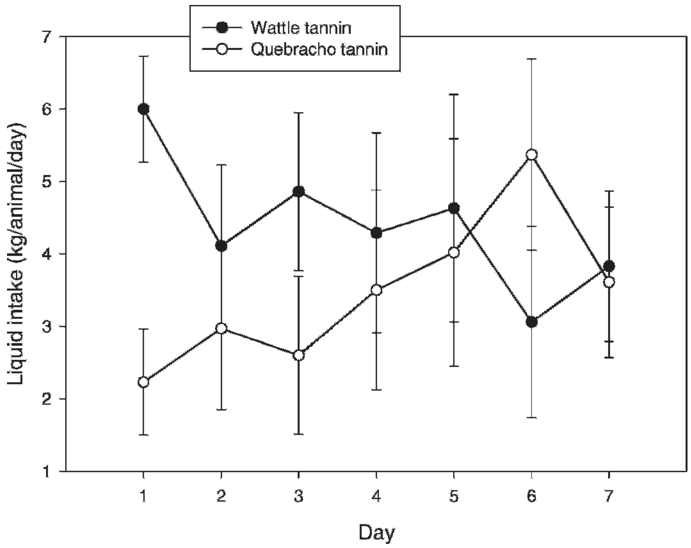

Figure 3. Least squares means of daily intake of water-based solutions of quebracho tannin and black wattle tannin (each prepared to provide about 0.75% of daily feed intake in tannin) for eight sheep over a 7-d trial (Trial 3). Vertical bars represent the SE associated with the means.

Total mean liquid intake for the whole trial was 63.9 $kg \cdot sheep^{-1}$, and mean daily liquid intake averaged across the whole trial was 9.12 $kg \cdot sheep^{-1}$. Mean daily tannin water intake averaged across the whole trial was 4.2 $kg \cdot sheep^{-1}$, and mean daily tap water intake averaged across the trial was 4.9 $kg \cdot sheep^{-1}$. This was 35.5% greater mean daily intake of tannin water than in Trial 1, when the tannin water was mixed to provide 33% more tannin with respect to daily feed intake, so the mean daily tannin intake was similar for the two trials, as was tap water intake. This suggests that the lambs were regulating their tannin intake, and this observation is consistent with those of Provenza and Malecheck (1984) and Provenza et al. (2000).

Trial 3

When sheep were offered a choice between solutions of QT water and WT water, they had inconsistent intakes of the two liquids ($P = 0.01$ for treatment by day interaction). They strongly preferred the liquid with the novel WT on the first day of the trial ($P < 0.001$), but showed no preference for either solution during the remaining days of the 7-d trial ($P \geq 0.15$; Fig. 3). The SE of the least squares means were 0.671 kg and 0.641 kg for intakes of the WT and QT waters, respectively.

Total mean liquid intake for the whole trial was only 55.0 $kg \cdot sheep^{-1}$, and the mean daily liquid intake averaged across the whole trial was only 7.9 $kg \cdot d^{-1} \cdot sheep^{-1}$. The lower total liquid intake for this trial compared to the previous trials suggests that perhaps when sheep had only tannin water to drink they drank less liquid. Their initial preference for the novel tannin solution may have been because they sensed it was different from the QT water and had "sensory specific satiety" (when animals satiate to a flavor with repeated exposure to it; Miller et al. 2001) or were trying to avoid the familiar QT water because they were experiencing negative postingestive effects from it. This trial provided no evidence that sheep preferred either QT or WT after 7 d of exposure to both.

IMPLICATIONS

Results from these trials support other observations that ruminant livestock will drink water with small amounts of CT, and strengthens the concept that this route of administration is possible for grazing livestock that may not consistently eat solid supplements containing CT. A practical and economical approach for providing CT in stock water needs to be developed before this approach can be used by producers.

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